

Statistical Case Study of Extracorporeal Shock Wave Lithotripsy

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Abstract- Extracorporeal Shock Wave Lithotripsy (ESWL) is one of the recent, most common ways of treating patients with urinary (renal and ureteric) stones through non-invasive destruction of stones [1]. Many reports and studies have shown its safety and success. It offers the patient less pain; much less discomfort and less severe complications usually associated with open surgery procedures.

This study does not aim to only establish few facts about this method of treatment, it, also, strives to suggest a statistical model of predicting and planning treatment, which, in turn, saves a great deal of staff's and patient's time. A whole list of factors was studied against each other, and distributions of these factors were deducted. Especially, we have studied the relationships between patient age and number of sessions through the knowledge of the stone size and number of stones.

1. INTRODUCTION

During the period of this study there was only one treatment apparatus, which was operated to its full potential. Patients from rural counties were referred to and treated in this center.

Factors considered were age, sex and the geographical location of the patient. Sizes, numbers and locations of stones were also recorded along with the number of sessions and shock waves (pulses). Destruction results and complications were observed. This case study looks into the results of treating a sample of 1000 patients using the ESWL system over a period of three years. This statistical sample was randomly chosen from 12000 records and was, afterwards, found to resemble the original society.

2. METHODOLOGY

Stone sizes of (0.4-6) centimeters were measured and destroyed, while larger stones and strangely shaped and located ones were referred to classical surgery (those numbered 7 patients; less than 1% only of the whole sample). Almost 40% of the stones were less than 1 cm in size, which could be attributed to early diagnosis and 50% measured between 1 and 2 cm; the rest had larger stones which we think is due to either late diagnosis or being from rural areas where health care standards are not as advanced as those in metropolitan areas. We, empirically, extracted the following tables:

TABLE 1
Statistical distribution of the sample with relation to stone size and no. of sessions

Stone Size (cm)	Number of Sessions					
	1	2	3	4	5	>5
$S \leq 1$	269	92	31	8	5	6
$1.5 \leq S < 1$	140	61	28	10	3	10
$2 \leq S < 1.5$	116	62	30	13	9	6
$S \geq 2$	40	25	23	26	9	21

TABLE 2

Statistical distribution of the sample with relation age and no. of sessions

Age average (years)	Number of Sessions					
	1	2	3	4	5	>5
5.5	16	7	2	1	0	1
15.5	21	12	6	2	3	0
25.5	143	42	12	7	1	10
35.5	141	46	23	10	8	13
45.5	106	49	22	12	7	11
55.5	52	24	20	9	1	6
65.5	25	16	8	4	1	2

TABLE 3

Statistical distribution of the sample with relation to no. of stones and no. of sessions

No. of Sessions	Number of Stones						
	1	2	3	4	5	6	7
1	450	66	12	5	2	1	0
2	157	51	13	4	0	0	0
3	55	29	6	2	0	1	1
4	27	14	4	0	0	0	0
5	6	5	3	1	0	0	1
>5	15	10	3	3	0	1	0

3. THE STATISTICAL CASE STUDY

In this section we are going to study statistically the relationship between patient's age and number of sessions needed to destruct the stone through the prediction of the stone size and the number of stones as seen in the cases below [2]. Now, from the above tables in section-2, we get the following tables:

TABLE 4
Relations among age average, no. of sessions and stone size

No. of sessions	Stone size average	Patient's age average
1	1.185	36.5
2	1.292	38.5
3	1.451	41.5
4	1.750	41.7

TABLE 5

Relations among age average, no. of sessions average and no. of stone

No. of sessions average	No. of stones	Patient's age average
1.63	1	5.5
2.26	2	15.5
2.56	3	25.5
2.80	4	35.5
3.07	5	45.5
3.33	6	55.5
4.00	7	65.5

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Case-1:

Consider the data in table-4, we will study the relationship between age and stone size as well as the relationship between stone size and number of sessions. This study is restricted to a selected range of ages between 35 years and 42 years. We used the SPSS statistical package to analyze the data.

Let

A be the **age** of a patient,
Z be the **stone size**, and
S be the **number of sessions**.

Thus we get the following models:

Model-1:

$$Z = 6.45 - 0.0122*A^2 + 0.000225*A^3 \quad (1)$$

Model-2:

$$S = -20.996 - 7.61*Z^2 + 11.3667*Z^3 \quad (2)$$

For model-1 (1) and model-2 (2), the coefficient of correlations are (0.894, 0.999) and the coefficients of determinations are (0.798, 0.999) respectively, which are very high and imply the existence of the relationships among the above variables and that our model fittings are good and promising [3]. We can, also, see the relationships in the above models graphically as follows:

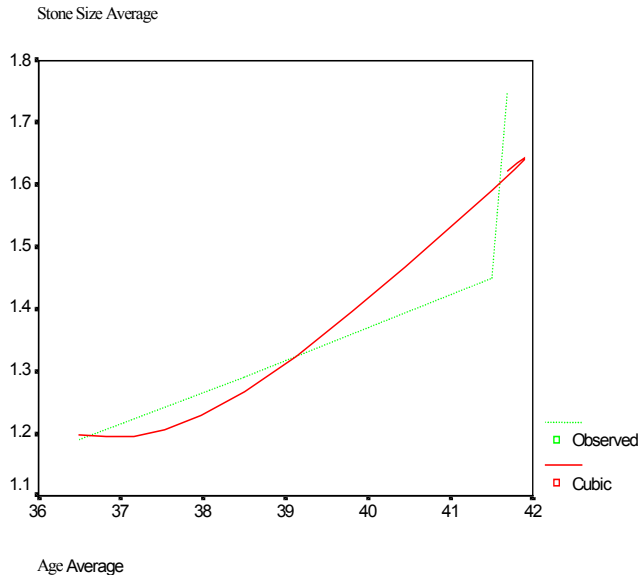


Fig. 1. The observed and predicted models between **age** and **stone size**

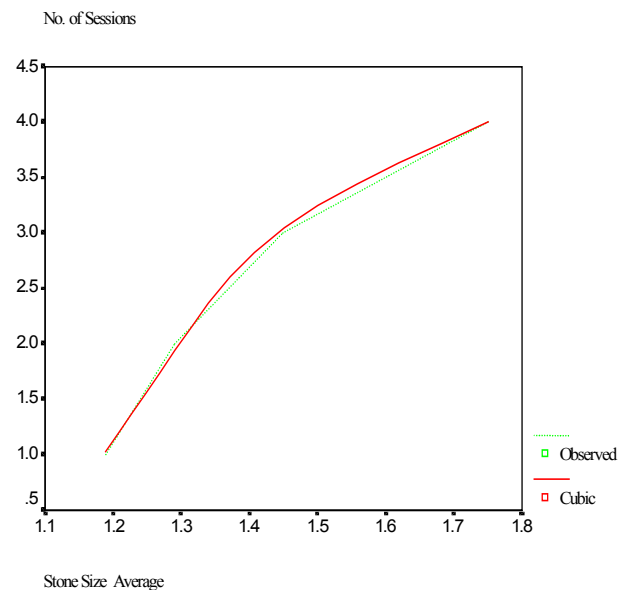


Fig. 2. The observed and predicted models between **stone size** and **no. of sessions**.

Case-2:

Now, consider the data in table-5, we will study the relationship between age and the number of stones as well as the relationship between the number of stones and number of sessions. Using the same statistical analysis as in case-1, letting N be the number of stones, we get the following models:

Model-1:

$$N = 0.45 + 0.1 * A \quad (3)$$

Model-2:

$$S = 0.631 - 0.263 * N^2 + 0.022 * N^3 \quad (4)$$

For model-3 (3) and model-4 (4), in this section, the coefficient of correlations are (1.0, 0.999) and the coefficients of determinations are (1.0, 0.998) respectively, which are also very high and imply the existence of the relationships among the above variables and that our model fittings are good and promising. Note that these models deal with all ages. But, it remains more useful and recommended to use the other models in case-1.

We can, also, see the relationships in the above models graphically as follows:

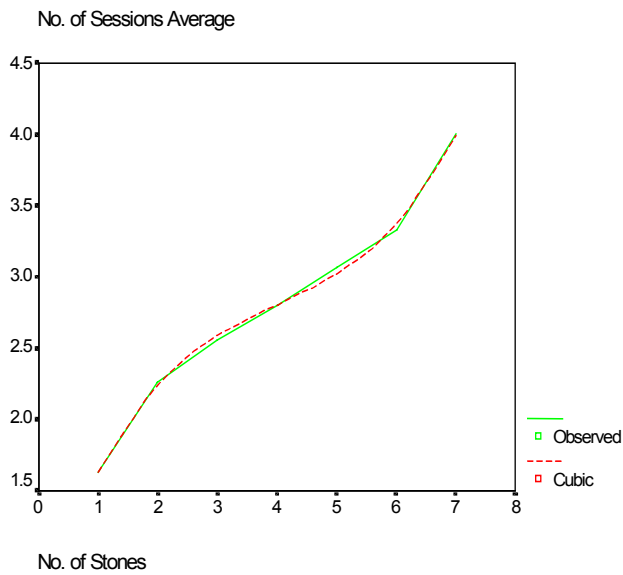


Fig. 3. The observed and predicted models between **age** and **no. of stones**.

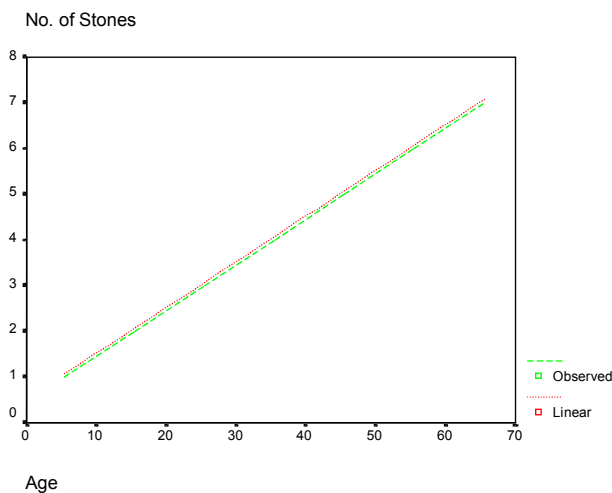


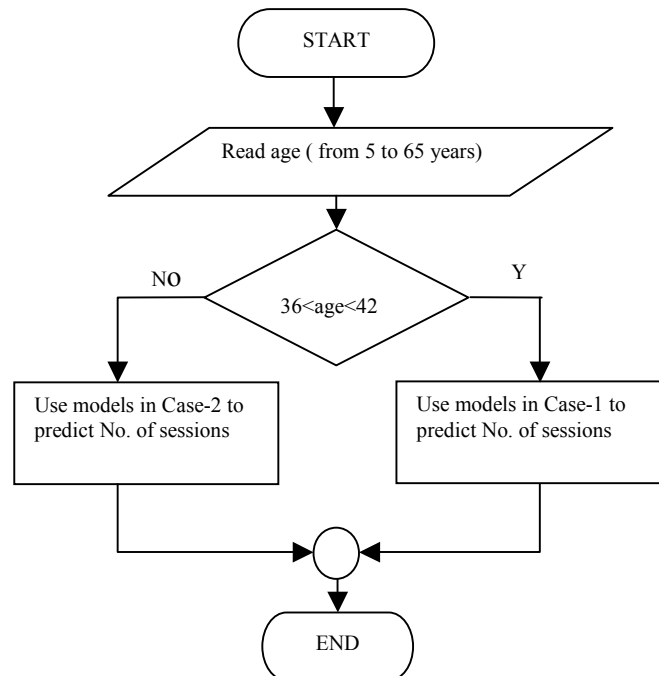
Fig. 4. The observed and predicted models between **no. of stones** and **no. of sessions**.

4. DISCUSSION

Looking into the results mentioned above, it is obvious that the distribution of the number of sessions and number of pulses per session against age of patient has been performed. The number of sessions and pulses required for stone size and for a number of stones were also plotted. Through these results, two dependencies could be deduced: first, guessing the number of sessions from age through the stone size, and,

second, guessing the number of sessions from age through the number of stones.

Thus, the following chart summarizes the results in the previous section.



5. CONCLUSION

This would very much help in predicting the length of the treatment period (which is in turn dependent on stone's number and size), and predicting the possible complications so precautions can be previously taken. These two separate regression models have been empirically verified with a very good resulting accuracy. A single multiple regression model has been suggested and is, currently under empirical verification to test for prediction accuracy. Other models regarding other factors are also being considered. It is hoped that these findings will assist in establishing a better health care services in this field.

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